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Invention: IMPROVED GRAIN DRILL WITH ACCURATE
 METERING OF THE RATE OF PLANTING OF SEED

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SPECIFICATION

To all whom it may concern:

Be it known that I, David E. Wilson, a citizen of the United States, residing at 4847 North Country Road 350 West, Greensburg, Indiana 47240, have invented certain new and useful improvements in

IMPROVED GRAIN DRILL WITH ACCURATE
METERING OF THE RATE OF PLANTING OF SEED

of which the following is a specification.

Improved Grain Drill With Accurate
Metering of the Rate of Planting of Seed

Technical Field

The present invention relates to grain drills used
5 for planting grains, such as wheat and soybeans and,
more particularly, to grain drills providing an
accurate rate of metering of the planting of seed.

Background Art

Numerous manufacturers sell grain drills which are
10 utilized extensively throughout the world for planting
grains, such as wheat, soybeans, oats, barley, etc.
Grain drills are towed by tractors and plant wide
swaths, such as 10 or more feet, with a single pass.
The towing of the grain drill with a tractor provides
15 the power for the metered planting of the seed into the
furrows. Grain drills further may be either of the no
till type, which do not require previous plowing and
discing of the ground, or the till type, which require
previously plowing and discing of the ground.

20 Commercially available grain drills are highly
sophisticated machines which provide tremendous
efficiency enabling farmers to plant large tracts of
land with grain. A typical soybean farmer may plant
a thousand or more acres a year with a single grain
25 drill. Thus, anything which adversely affects the
operation of a grain drill has tremendous impact on the
economics of farming using grain drills.

Commercially available grain drills do not contain
on-board devices which permit the farmer to accurately
30 determine the rate of planting of seed per acre in
terms of weight per acre. A grain drill has an acreage
counter which indicates approximately the number of
acres which have been covered during planting.

However, commercially available grain drills do not have on-board weighing devices which permit the weight of seed, such as wheat, soybeans, oats, barley, etc. to be accurately determined while planting is ongoing.

- 5 Seeds may be purchased in bags having a uniform weight, such as 50 lbs., which permits the farmer to load the hopper of a grain drill with an accurately weighed amount of seed which ultimately permits the farmer to determine the rate of planting of seed in
- 10 weight per acre by dividing the total number of acres which have been planted during the time that the seed was planted by the number of preweighed bags used to fill the grain drill seed hopper times the weight of seed per bag. The filling of the hopper with
- 15 preweighed bags of seed is cumbersome, requires the opening of individual bags involving substantial time, and prevents the farmer from purchasing seed in bulk. Seed purchased in bulk is cheaper which would result in a net savings of the cost per acre for planting if the
- 20 farmer could accurately determine the weight of the bulk seed which would permit the foregoing calculation of pounds of seed per acre to be made to enable the farmer to determine the actual rate of planting in terms of weight per acre. However, the purchase of
- 25 seed in bulk does not provide the farmer with an accurate determination of the weight of seed which is placed in the hopper. Therefore, after the filling of a grain drill hopper with seed from a bulk source is completed, while the farmer can determine approximately
- 30 the total number of acres which were planted from the acre counter, there is no accurate measure of the weight of the seed which was placed in the hopper from a bulk purchase or container.

Thus, farmers today who use state of the art grain drills are faced with a constant dilemma of how to accurately determine the rate of planting of seed in terms of weight per acre to accurately control the rate of planting which permits optimization of crop yield. That dilemma either requires the purchase of seed in preweighed bags with its attendant inefficiencies and additional expense or makes it impossible for the farmer to calculate the weight rate of planting of seed in an accurate manner which results typically in not planting the grain seed at the ideal weight rate per acre which is necessary to optimize yield.

Furthermore, even if the farmer knows precisely the weight of seed which is placed in the hopper of a grain drill, there is no current mechanism for "on the fly" determination of the rate of planting of seed in pounds per acre as the drill is operated before the seed hopper is emptied. Commercially available grain drills have a mechanical calibrated metering device which has a linear scale having increasing numbers which represent an increased rate of planting. However, because of the variation of the size of seed which is planted and the different types of seeds which are planted with a grain drill, the numerically graduated scale for controlling the rate of planting provides nothing about the weight rate of seed being planted and provides information on only a relative rate of planting.

Experienced farmers develop an understanding of the desired rate of planting of seed in terms of weight measure per acre. If the farmer accurately plants seed with a grain drill at the optimum rate, the yield of the resultant crop is optimized and further, the overall cost of seed to obtain the maximum crop yield is reduced. On one hand, if less than the optimum

quantity of seed per acre is planted, the resultant yield will be less than the optimum yield resulting in the farmer realizing less income per acre than would be realized if the optimum rate of seed was planted per acre. On the other hand, if the rate of planting of seed is too great per acre, a decreased yield is realized, which is less than the optimum yield, resulting in the waste of seed which represents a substantial expense to the farmer. Also, the resultant plants may be down because of their high density, which makes it difficult for the farmer to combine the plants at harvest. For example, if a farmer is planting 1,000 acres of soybeans with a grain drill and makes a mistake of overestimating the rate of planting of seeds at a rate of 5 lbs. per acre, a total of 5,000 lbs. of wasted seed occurs which represents a substantial expense over \$1,000.00 with no return on investment and a possible lessened yield because of over density in planting.

Additionally, with current state of the art grain drills, while the rate of deposition of seed may be varied by changing the setting of the control of the relative rate of planting of seed, there is no way for the farmer on the fly to determine the actual rate of planting of seed by planting only a small area. As previously described, the only way to precisely determine the weight rate of planting seed is to accurately count the number of preweighed bags of seed which are placed in the hopper and after the entire hopper is planted, the total weight of seed in the hopper is computed by multiplying the number of bags used by the weight of seed per bag and that total weight is divided by the number of planted acres. This process is time consuming and wasteful because if the rate of planting of seed is set either too high or too

low, all of the land which was planted with the seed from the full hopper is not optimally planted at the right rate to maximize the yield and to reduce the expense of seed to the minimum amount per acre.

5 Additionally, while commercially available grain drills may contain a sight glass for viewing if there is seed in the drill, such viewing devices do not provide a view when the drill is close to being empty. This forces the farmer into the situation that it is
10 possible for the hopper to be empty while the farmer is continuing to plant seed. The resultant acreage must be reseeded or worse, may not be seeded at all until after the seed germinates. In any event, because of the pressures that are involved with weather conditions
15 to plant seed with a grain drill at the right time, the farmer requires the ability to know precisely when additional seed must be added to the hopper which may necessitate a helper to go to a seed supplier to obtain seed at the end of the day after the seed supplier is
20 closed. If the farmer cannot accurately determine what the weight of seed is in the hopper at all times, it may be impossible to determine with enough lead time that additional seed must be purchased from the seed supplier or otherwise obtained from the farmer's
25 storage of seed.

 Thus, while it is highly desirable for a farmer to know the weight rate of planting of seed per acre and further the quantity of seed in the hopper of a grain drill at all times, none of the currently commercially
30 available grain drills permit an accurate determination on the fly of the amount of seed present in the hopper and furthermore, do not permit the calculation of the weight rate of planting of seed over a small number of acres less than the number of acres required to empty
35 exhaust all of the preweighed seed which has been

placed in the hopper. There is a long-felt need in farming to provide a low cost and accurate device for determining the weight rate of planting of seed per acre and further the weight of seed at all times in the
5 hopper of a grain drill.

Fig. 1 schematically illustrates a Model 750 no till grain drill 10 manufactured by the John Deere Company. The grain drill 10 is comprised of a rigid frame 12 having a plurality of wheels 14 for supporting
10 the drill during rolling over a surface of ground to be planted with grain and a grain hopper 16 for containing the grain to be planted in the ground. The aforementioned grain drill is sold to farmers and is exemplary of the state of the art of grain drills which
15 do not have an on-board weighing mechanism for determining the weight of seed in the grain hopper 16.

The frame 12 has a pair of longitudinally extending frame members 18 which are hollow in rectangular hollow cross section and which are part of
20 the rigid support of the grain drill. The frame 12 further has a plurality of cross frame members, not illustrated, which extend across the full width of the drill to form a rectangular space frame for supporting the weight of the seed hopper 16 across the width of
25 the grain drill. While Fig. 1 illustrates a single seed hopper 16, it should be understood that wider grain drills have two seed hoppers bolted side by side to the frame, as illustrated in Fig. 3, which represents a John Deere Model 750 grain drill, such as,
30 for example, permitting a 20-foot grain drill to be formed from two 10-foot seed hoppers which are individually used on 10-foot grain drills. The plurality of cross members are connected to the longitudinally extending frame members 18 to define the
35 overall rigid space frame structure from which the

plurality of wheels 14 are suspended. Each hopper 16 is bolted to the longitudinally extending members 18 at four corners thereof. The entire frame structure of the grain drills of Figs. 1 and 3 is conventional and well known.

Fig. 2 illustrates an enlarged section of the longitudinal side of the grain drill 10 of Fig. 1. As illustrated, the outboard portion of the longitudinally extending frame member 18 is removed by removing bolts (not illustrated) to permit access from underneath in opening 19 to the horizontally extending member 22 as illustrated. In the Model 750 and other commercially available grain drills from John Deere, a total of eight holes 24 are drilled through the horizontal member 22 and face the bottom horizontal surface 26 of hopper 16. Pairs of the holes 24 face the four bottom corners of hopper 16. Eight tapped holes 28 extend through the bottom horizontal surface 26 and are in alignment with the holes 24 to permit the rigid attachment of the hopper 16 to the frame 12 by threading fasteners 30 through the hole 24 into engagement with the threads of a corresponding hole 28 as illustrated. The use of fasteners 30 in the prealigned holes 24 and 28 permits the farmer to readily remove the hopper if service is required or otherwise removal is necessary and further simplifies the manufacturing process. The fasteners 30 provide an extremely strong and rigid connection so that the hopper 16 does not shift relative to the frame 12 and further applies the weight of the grain in the hopper to the frame 12 when loaded and rolling across the surface of the ground during planting in the conventional manner.

As illustrated, the opening 19 on the outboard side of the horizontally extending frame members 18 provides access to secure the fasteners 30 from underneath to the holes 24 and 28 at the manufacturing facility and thereafter to permit the farmer to have access if necessary to either tighten the fasteners or to remove them if the hopper 16 is to be removed from the frame 12.

The grain drill 10 contains a conventional acreage counter 32 which provides a running count of the number of acres planted and consists of a rotary set of wheels similar to that of a speedometer which are calibrated to read the actual number of acres which are planted and a control 34 for setting the rate of planting of seeds. The control 34 has a series of teeth which interlock with a movable handle which is rotated relative to a graduated numerically calibrated scale for setting the rate of planting. The rate of planting is calibrated such that higher numbers indicate a higher rate of planting but not in terms of a calibrated seed weight rate per acre. However, it should be understood that while the acreage counter is reasonably accurate in practice, there is no available mechanism to calibrate the weight per acre of seeds which are being planted purely by use of the control 34 with the only effective mechanism being to distribute preweighed seeds and divide the weight by the number of acres planted as described above.

Fig. 3 illustrates a prior art grain drill 11 which is generically in accordance with Fig. 1, except that two seed hoppers 16 are mounted side by side. Grain drills 11 for planting wide swaths include multiple hoppers 16, such as two side by side hoppers as illustrated. The frame 12 is wider than the prior art of Fig. 1 to support the increased weight, but

overall the function of the grain drill 11 is the same as the prior art grain drill 10 of Fig. 1 and also has the same deficiencies as described above of not providing the farmer with the ability to determine the weight of seed in the hopper and the weight rate of planting of seed on the fly.

United States Patent 2,449,915, 4,465,211, 4,539,921, 4,697,173, 5,595,131 and 5,323,721 disclose systems used for the planting of seeds. United States Patent 4,465,211 discloses a weight indicator for a seeder but such device has no application to grain drills because of its construction. United States Patent 2,449,915 discloses an indicator for indicating the level of seed in a seed hopper but does not disclose any weighing mechanism. United States Patent 4,539,921 discloses a modular drill frame construction. United States Patent 4,697,173 discloses a monitoring apparatus which monitors various parameters of agricultural seeding, including the level of seeds stored in a hopper of a seeder and a sensor for providing a measure of the rate of movement of the seeder over the ground. United States Patent 5,959,131 discloses a flexible and resilient support for a grain box of a grain drill. United States Patent 5,323,721 discloses a planter monitoring system which determines a number of parameters of planting. None of the aforementioned patents discloses a mechanism which may be used to accurately weigh the seed within a hopper of a grain drill and to provide the farmer with an accurate measure of the weight rate of seeds being planted.

Disclosure of the Invention

The present invention is an improved grain drill which senses the weight of seed grain in a hopper which contains the seed to be planted and further, a method
5 for modifying a grain drill having a frame including a plurality of wheels for supporting the grain drill during rolling over a surface of ground to be planted with grain and a hopper joined to the frame for containing the seed grain to be planted to sense the
10 weight of seed grain in the hopper. In accordance with the invention, a support is joined to opposed sides of the frame and to spaced apart locations of the hopper to transfer weight of the hopper to the frame and includes at least one weight sensing device which
15 senses the weight of seed grain in the hopper transferred through the support to the frame. The at least one weight sensing device provides an output of the sensed weight of the seed grain in the hopper which is coupled to a display for displaying the weight of
20 the seed grain contained in the hopper so as to provide the operator of a tractor towing the grain drill with an accurate indication of the weight of seed grain contained in the hopper at all times.

The present invention provides substantial
25 advantages to operators of grain drills in comparison to the prior art described above. By providing the operator of a grain drill with an accurate weight of the seed in the hopper at all times, including during planting operations, several operational advantages are
30 realized. First, the control for setting the rate of planting may be readily accurately calibrated for diverse types and different sizes of seed grains in terms of weight per acre being planted after the planting of a few acres to fine tune the rate of
35 planting to a desired weight rate of grain seed per

acre. The calibration is simply achieved by the operator determining the weight of the seed grain, which is planted over a small number of acres which are indicated to have been planted by the acreage

5 counter, to calculate the weight rate of seed grain planted per acre by simply dividing the total weight of seed grain planted by the number of acres planted. If the initial setting of the control controlling the rate of planting in the prior art is either too high or too

10 low, the control is then moved in the opposite sense to adjust the rate of planting of seed grain to the desired planting rate of weight per acre which the farmer wishes to achieve during planting. The precise calibration of the rate of planting of seed grain in

15 terms of weight per acre can be achieved after an initial calibration and possibly one more calibrations after resetting of the control controlling the relative rate of planting to achieve the desired rate of planting in terms of weight per acre which provides the

20 farmer with a substantial cost savings because, as explained above, planting seed grain at the optimum rate provides the greatest crop yield at the smallest possible seed grain cost per acre thereby maximizing the farmer's economic yield per acre. Additionally,

25 the invention by providing the farmer with a continuous display of the weight of seed grain in the seed grain hopper, enables the farmer to make arrangements for the acquiring of additional seed grain to refill the hopper prior to running out of seed grain which, in the prior

30 art, often resulted in a substantial loss of time to the farmer because the farmer was required to determine how much area was not planted because the hopper had run out of seed grain. Furthermore, the continuous display of the weight of seed grain in the hopper

35 permits the farmer to exhaust one type of seed grain in

the hopper and change over to another type of seed grain without substantial mixing of the two seed grain types. It is highly desirable for farmers to use different types of seed grains for planting a crop to provide a hedge against a bad yield for one seed grain type by providing another seed grain type during the same planting which will provide a higher yield in different weather conditions which would not produce a high yield for the first seed grain type. Finally, as explained above, the farmer may purchase seed grain in bulk quantities which is cheaper than buying it in preweighed bags to thereby lessen the cost of seed grain per acre in planting and lessen the time and effort required to load the hopper of the grain drill by permitting use of powered conveyers or other types of seed grain transporting devices which supply seed grain from bulk containers which eliminates the hand labor and low efficiency of opening individual seed grain bags.

When the present invention is used to retrofit an existing grain drill, such as a drill from the John Deere Company, as illustrated in the prior art of Figs. 1-3, only minor modifications are required to the existing unit because the fitting of a support, which transfers weight of the seed grain in the hopper to the frame, is retrofitted to use the same holes which are used to attach the frame to the hopper with fasteners as described above at the time of manufacturing or, alternatively, requires simple additional attachments of the support to the hopper and the frame.

The purchase cost of the present invention from a farm equipment supplier may be recovered by a farmer in a single year by permitting the farmer to accurately calibrate the weight of planting of seed grain which

saves wasted seed grain and lowered yield from over planting and reduced yield from under planting.

Furthermore, while a preferred embodiment of the present invention locates the support for transferring
5 the weight from the hopper through a weight sensing device in the support directly underneath the hopper and within the longitudinally extending frame members on both sides of the drill, it should be understood that the present invention may be alternatively
10 practiced with a support transferring the weight from the hopper outboard of the longitudinally extending frame members through a weight sensing device to the frame at a point of attachment on an outside surface of the longitudinally extending frame member so as to
15 permit any design of grain drill, including those without any accessible opening underneath the frame 12, as described in conjunction with the prior art of Fig. 2, to be utilized with the practice of the present invention.

20 The present invention utilizes weight sensing devices which preferably are commercially purchased load cells which are configured into the support to transfer the weight of the hopper to the frame for producing an output signal which is displayed from
25 a commercially available display unit which decodes the individual weights sensed by each load cell and converts the individual weights sensed by each load cell into a cumulative total weight display of the seed grain contents of the hopper. Each of outputs from the
30 individual weight sensing devices located in the support are electrically connected to the display with individual electrical cables which provides the aforementioned display of the total weight sensed by each of the weight sensing devices. Preferably, at
35 least four weight sensing devices are utilized with the

present invention. In applications of the invention where two or more hoppers are used in a side by side configuration, such as Fig. 3, an odd number of weight sensors may be used per hopper when a common support
5 for two frames being utilized inboard of the sides of the grain drill.

The present invention is a grain drill comprising a frame having a plurality of wheels for supporting the grain drill during rolling over a surface of ground to
10 be planted with grain; a hopper for containing the grain to be planted in the ground; a support which is joined to opposed sides of the frame and to spaced apart locations of the hopper to transfer weight of the hopper to the frame, the support including at least one
15 weight sensing device which senses a weight of seed grain in the hopper transferred through the support to the frame and provides an output of the sensed weight of the seed grain in the hopper; and a display, coupled to the output, for displaying the weight of seed grain
20 contained in the hopper. The support comprises a pair of weight bearing supports which are respectively joined to opposed sides of the frame, each weight bearing support including first and second vertical parts which are respectively attached to the hopper at
25 the spaced apart locations separated along a longitudinal dimension of the grain drill and a horizontal part joined to the vertical parts and attached to the frame. The at least one weight sensing device comprises first and second load cells associated
30 with each of the pair of weight bearing supports, the first load cell being loaded with weight transferred from the first vertical part to the horizontal part and the second load cell being loaded with weight transferred from the second vertical part to the
35 horizontal part. A first end of the first and second

vertical parts is attached to the hopper and a second end of the first and second vertical parts is respectively attached to spaced apart positions of the horizontal part to transfer the weight of the seed grain in the hopper to the horizontal part; and the horizontal part has first and second horizontal extensions, the first horizontal extension having a first end which is coupled to the frame and includes the first load cell and the second end which is deflected downward by the weight of the seed grain in the hopper and which is attached to the second end of the first vertical part and the second horizontal extension having a first end which is attached to the frame and includes the second load cell and the second end which is deflected downward by the weight of the seed grain in the hopper and which is attached to the second end of the second vertical part. The support frame includes at each of the opposed sides a horizontal member, each horizontal member having at least first and second spaced apart holes extending vertically through the horizontal member and which respectively receive and allow vertical movement of a portion of the first and second vertical parts, the holes restricting horizontal movement of a hopper relative to the frame by confining the portion of the first and second vertical parts to within the holes. The first and second vertical parts comprise a horizontal piece attached to one end of a vertical piece and another end of the vertical piece being the second end of the vertical part, at least one connector extending from the horizontal piece through one of the holes and being vertically moveable therein and into engagement with the hopper. At least a pair of connectors extend from the horizontal piece at opposed ends thereof spaced from a point of attachment of the

vertical piece to the horizontal piece. Each connector is threaded and engages threads in the hopper at one of the spaced apart positions of the hopper. A bushing is located in each hole and securely engages each

5 connector to prevent horizontal movement of the connector relative to the bushing. The spaced apart positions are located at four corners of the hopper and the support is attached to the four corners by engagement with a bottom part of the hopper.

10 Each weight bearing support does not to extend beyond a width of a portion of the frame to which the weight bearing support is attached or, alternatively, at least one of the weight bearing supports is mounted at least in part extending beyond a width of a portion

15 of the frame to which the weight bearing support is attached.

A method for modifying a grain drill having a frame having a plurality of wheels for supporting the grain drill during rolling over a surface of ground to

20 be planted with seed grain and a hopper joined to the frame for containing the seed grain to be planted comprises raising the hopper upward from the frame to separate the hopper from being joined to the frame; positioning a support between the hopper and the frame

25 to join the frame to opposed sides of the frame and to spaced apart locations of the hopper to support the hopper in a raised position above the frame, the positioned support transferring weight of the hopper to the frame, including at least one weight sensing device

30 which senses a weight of the seed grain in the hopper transferred through the support to the frame and which provides an output of the sensed weight of the seed grain in the hopper; and providing a display for displaying on the grain drill the weight of the seed

35 grain contained in the hopper. The construction of the

support utilized with the foregoing method is preferably as described above.

Brief Description of Drawings

Fig. 1 is a perspective schematic view of a prior art grain drill.

Fig. 2 is an enlarged view of a portion of the prior art grain drill of Fig. 1 showing the joining of the seed hopper directly to the frame with threaded fasteners.

Fig. 3 is a prior art view of a grain drill having multiple side by side seed hoppers.

Fig. 4 is a side elevational view of a first embodiment of a grain drill including a support in accordance with the invention for transferring weight from the seed hopper to the frame which may be used to modify the prior art grain drill of Figs. 1 and 2 to display a weight of seed grain in the hopper.

Fig. 5 is a sectional view of Fig. 4 taken along section line 5-5 of Fig. 4.

Fig. 6 is a sectional view of Fig. 4 taken along section line 6-6 of Fig. 4.

Fig. 7 is a sectional view identical to Fig. 6 illustrating the effect of weight loading from the hopper on the support.

Fig. 8 is a top plan view of a grain drill including the support of the invention in accordance with Figs. 4-7.

Figs. 9-11 illustrate a second embodiment of a grain drill including a support in accordance with the present invention which has the support extending outside the vertical side wall of the longitudinal frame members and the outboard sides of the grain drill.

Figs. 12-14 illustrate a third embodiment of a grain drill in accordance with the invention having side by side grain hoppers such as the prior art of Fig. 3 including a support having inboard weight bearing supports located at opposed corners of side by side hoppers.

Fig. 15 is an exploded diagram of a commercial embodiment of the present invention which may be retrofitted to a Model 750 grain drill from the John Deere Company which is very similar to the first embodiment of the support of Figs. 4-8.

Like reference numerals identify like parts throughout the drawings.

Best Mode for Carrying Out the Invention:

Figs. 4-8 illustrate a preferred embodiment 50 of a grain drill in accordance with the present invention which is a modification of the prior art of Figs. 1-3 described above. The prior art has been modified to provide a support 52 which is joined to a first opposed side 54 and a second opposed side 56, as illustrated in Fig. 8, of the frame 12 and to spaced apart locations 58 of the hopper 16 which are preferably at the four corners of the bottom surface 26 thereof to transfer weight of the hopper and seed grain therein to the frame. The support 52 includes at least one weight sensing device 60 which each preferably is a commercially purchased load cell of the one inch weigh bar type having a calibration diameter of 2-1/8" manufactured by the Weight Tronix Company of Fairmont, Minnesota. The weight sensing devices 60 function to generate an accurate output of sensed weight which is a function of vertically downward deflection 70 caused by the application of the weight of the seed grain 71

in the hopper 16 thereto as described below. Each of the weight sensing devices 60 has an output cable 62 which is connected to a display 64. The display 64 is preferably Part Number 12980 also manufactured by
5 Weight Tronix Company, which is designed to total the sensed output weights from each of the weight sensing devices 60 and generate a display 66 of the total weight of seed grain 71 in the hopper 16 to enable the farmer to visually determine from a tractor towing the
10 grain drill 50 the weight of seed grain in the hopper at all times. It should be understood that the invention is not limited to the particular choice of weight sensing devices 60 in the form of load cells and the display 64.

15 In a preferred form of the present invention, the support 52 is comprised of a pair of weight bearing supports 68 which fit into the hollow space 19 underneath the horizontal member 22 of the longitudinally extending frame members 18 as described
20 above in Fig. 2. As illustrated in Fig. 8, the individual weight bearing supports 68, which comprise the support 52, are located at opposed sides of the grain drill and are separated by the width thereof. As a result of the weight bearing supports 66 fitting
25 below the horizontal member 22 within the hollow rectangular cross section of space 19 of the longitudinally extending frame members 18, the weight of the hopper 16 is transferred directly downward through the holes 24 through each weight bearing
30 support 66 to the frame 12 as described in more detail below. The transfer of the weight from the hopper 16 directly downward to the weight bearing supports 68 causes a vertically downward deflection 70 of the individual weight sensing devices 60 proportional to
35 the sensed weight which produces the aforementioned

output of the weight 66 of seed grain 71 in the hopper 16 on display 64.

Each weight bearing support 66 includes first and second vertical parts 72 and 74 which are respectively
 5 attached to the hopper 16 at the spaced apart locations 58 of the bottom surface 26 of the hopper which are preferably at the four corners of the hopper and mounted in a line parallel to a longitudinal dimension of the longitudinally extending frame
 10 members 18 of the grain drill and a horizontal part 76 joined to the vertical parts and attached to the frame 12. As illustrated, each weight bearing support 68 includes first and second weight sensing devices 60. The first weight sensing device 60 of the
 15 weight bearing support 68 is loaded with weight transferred from the first vertical part 72 to the horizontal part 76 and the second weight sensing device is loaded with weight transferred from the second vertical part 74 to the horizontal part 76. A first
 20 end 78 of the first and second vertical parts 72 and 74 is attached to the hopper 16 and a second end 80 of the first and second vertical parts is respectively attached to spaced apart locations of the horizontal part 76 to transfer the weight of the seed grain 71 in
 25 the hopper to the horizontal part to load the weight sensing devices 60 therein. The horizontal part 76 has a first horizontal extension 82 and a second horizontal extension 84. The first horizontal extension 82 has a first end 86 which is coupled to the frame 12 and
 30 includes the first load sensing device 60 and a second end 88 which is deflected downward as indicated by arrow 70 by the weight of the seed grain 71 in the hopper 16 and which is attached to the second end 80 of the first vertical part 72 and the second horizontal
 35 extension 84 has a first end 90 which is coupled to the

frame 12 and includes the second weight sensing device 60 and a second end 92 which is deflected downward by the weight of the seed grain in the hopper as also indicated by arrow 70 and which is attached to the second end 80 of the second vertical part 74.

As described above, the frame 12 includes at each of the opposed sides of the longitudinally extending frame member 18, a horizontal member 22. Each horizontal member 22 has at least first and second spaced apart holes 24 extending vertically through the horizontal member and which respectively slidably receive a portion of the first and second vertical parts 72 and 74. The holes 24 restrict horizontal movement of the hopper 16 relative to the frame 12 by confining the portion of the first and second vertical parts 72 and 74 to within the holes.

Each of the first and second vertical parts 72 and 74 have multiple parts. A horizontal piece 96 is attached to one end 98 of a vertical piece 100. The other end of the vertical piece 106 is the second end 80 of the first and second vertical parts 72 and 74 which respectively are attached to the ends of first and second horizontal extensions 82 and 84. A pair of threaded connectors 102 project upward from the horizontal piece 96 through the holes 24 and into threaded engagement with the threads within holes 28 of the bottom 26 of the hopper 16. A nut 101, as illustrated in Figs. 6 and 7, may be placed onto a portion of the threads of the connectors 102 which project upward beyond a bottom surface of the bottom 26. Furthermore, the invention is not limited to any type or number of connectors but threaded connectors are preferred because they may be chosen to have threads which engage the threads in the bottom 26

of the hopper 16 which are used by the manufacturer to attach the hopper to the frame 12. The use of the aligned holes 24 and 28 and threaded connectors 102 to engage the threads in the holes 28 in the bottom of the hopper 16, which are used by the manufacturer, facilitates the retrofitting of support 52 to an existing grain drill in accordance with the prior art of Figs. 1-3.

The aforementioned portion of the first and second vertical parts 72 and 74 which engages the hopper 16 should have at least one connector 102 extending from the horizontal piece 96 and through one of the pair of holes 24 and 28 and into engagement with tapped threads in the bottom horizontal surface 26 of the hopper 16. Preferably, as illustrated, a pair of connectors 102 extend from each horizontal piece 96 to engage a different one of the four corners 58 of the hopper 16 to provide a four point suspension of the hopper which provides both high rigidity and even weight transfer of the seed grain 71 in the hopper 16 to the weight sensing devices 60 within the weight bearing supports 68. Bushing 104 fits slidable within an enlargement of the hole 24 of the prior art of Figs. 1-3 within horizontal member 22 and receives the threaded connectors 102 which transfer the weight of the seed grain 71 from the hopper 16 down through the load sensing devices 60 to the frame 12.

Each connector 102 preferably is attached to respective ends of the horizontal piece 96 by drilling holes in the respective ends and using a nut 105 and washer 106 to secure the connector into engagement with the hole. Furthermore, a block 108 is attached to the spaced apart locations 58 of the hopper 16 with threaded connectors 110. The block 108 has a hole 112 drilled therein to tightly receive the bushing 104 to

reinforce the sliding engagement of the support 52 relative to the horizontal member 22.

Additionally, each weight bearing support 68 has a pair of spaced apart support feet 114 which extend vertically downward from a horizontal rod 116 to which the individual weight sensing devices 60 are attached. Also attached to horizontal rod 86 is a bracket 118 which is secured to the frame 12 by a threaded fastener 120. The feet 114 transfer the weight of the hopper 16 loaded directly onto the weight sensing devices 60 as a consequence of being located relatively close to the ends 86 of the attachment of the weight sensing devices 60 to the outboard ends 122 of the horizontal rod 116.

The foregoing grain drill may be retrofitted to an existing grain drill such as, but not limited to, the prior drills of Figs. 1-3 by raising the hopper(s) 16 from the illustrated portions of Figs. 1-3 to separate the hopper from being joined to the frame 12. Thereafter, the aforementioned support 52, as described above, is positioned between the hopper 16 and the frame 12 as described above in Figs. 4-7 to join the support to the opposed sides 54 and 56 of the frame and to spaced apart locations 58 of the hopper to support the hopper in a raised position above the frame as illustrated in Figs. 4-7. The display 64 is attached to the frame 12 by welding a support bracket to the frame or attaching the support bracket to the frame with threaded connectors at a position permitting an operator to view a numerical display of the weight 66 from the tractor pulling the grain drill. The positioned support 52 transfers the weight of the hopper 16 to the frame 12 in the manner as described above. Thus, the present invention is applicable to both new construction of grain drills or to

retrofitting existing grain drills without extensive modification of the manufacturing process or extensive labor for the retrofitting process as a consequence of the support 52 being positionable in the previously
5 drilled holes 24 in the horizontal member 22 of the longitudinally extending members 18 and the previously drilled holes 28 of the bottom 26 of the hopper.

While the invention in a preferred embodiment mounts the support 52 directly below the horizontal
10 member 22 within the opening 19 of the longitudinally extending frame members 18, in grain drills which do not have access from below the upward most part of the frame 12 facing the hopper 16, the load of the hopper may be transferred outboard of the outside face of the
15 frame 12 of the grain drill with a support 130 as illustrated in a second embodiment of a grain drill in Figs. 9-11 in accordance with the present invention. Alternatively, the load of the hopper 16 may be transferred at least in part inboard of the outside
20 longitudinal frame members 18 to an inside face of the frame 12 of the grain drill with a support 170 as illustrated in a third embodiment in Figs. 12-14.

Figs. 9-11 illustrate a second embodiment of a support 130 in accordance with the present
25 invention which differs from the first embodiment 52 in that the support does not fit directly vertically below the hopper 16 in the space 19 as illustrated in Fig. 4. Certain reference numerals which are common to Fig. 4 have been omitted. Instead, the support 130 has
30 a plurality of angle brackets 132, 136, 140 and 144 which directly bolt to a vertical outside side faces of the hopper 16 and the longitudinal frame members 18 as illustrated. The first angle bracket 132 bolts to the vertical sidewall of the hopper 16 with a connector 134
35 and the second angle bracket 136 bolts to the vertical

sidewall of the longitudinal frame member 18 with connector 138. The angle bracket 140 bolts to the vertical sidewall of the longitudinal member 18 with connector 142 and the angle bracket 144 also bolts to the vertical sidewall of the longitudinal member 18 with connector 146. As illustrated, this embodiment transfers the weight of the seed in the hopper 16 from the hopper through the support 130 through the at least one load sensing device 60 to the longitudinal frame member 18 via the foregoing angle brackets 132, 136, 140 and 142. This embodiment preferably has four weight sensing devices deployed in the same manner as the first embodiment. This design may be used to retrofit grain drills or for a new construction of grain drills where there is no opening 19 directly below the hopper 16 as in the embodiment of Figs. 4-8.

The third embodiment of a grain drill of the present invention includes a support 170 which differs from the first two embodiments in providing the total weight of grain within tandem hoppers 16 as illustrated in Figs. 12-14. Certain reference numerals which are common to Fig. 4 have been omitted. A plurality of weight bearing supports are utilized in the third embodiment 170. The weight bearing supports 68 are located on the outboard sides as illustrated and may be identical to the first and second embodiments as described above. On the inboard sides of the tandem hopper 16, a pair of weight bearing supports 170 are located diagonally at the respective front and rear corners of the inboard sides of the individual hoppers 16 as illustrated in Fig. 12. A pair of plates 172, as illustrated in Fig. 13, are disposed at the diagonal corners of the tandem hoppers 16 to provide a support at the front and rear of the hoppers.

Each plate 172 is bolted to the individual tandem
hoppers 16 with fasteners 174. Individual weight
sensing devices 60 are located at each of the weight
bearing supports 170 which provide a two point support
5 for the inboard sides of the tandem hoppers 16 at the
diagonal corners 190 that transfers the weight of the
seed in the hoppers to the longitudinal frame
members 18. Individual fasteners 176 attach
a member 188 to the plate 172 which is attached to the
10 corner 190 of the side by side hoppers with
fasteners 174. The member 188 is also bolted to the
longitudinal frame member 18 with fasteners 192.
An angle bracket 194 attaches the inboard end of
horizontal rod 116 to the horizontal member 18. The
15 outboard end 122 of the horizontal rod 116 is attached
to the weight sensing member 60. The overall function
of the third embodiment of the weight bearing
supports 170 is similar to that of the first and second
embodiments. The distinction is that the weight of the
20 seed in the tandem hoppers 16 on the inboard side is
transferred through the weight bearing supports to the
side of the longitudinal frame members 18 through the
use of plates 172 which provide support for the overall
weight of the hoppers through the weight bearing
25 supports including the at least one weight sensing
device 60 instead of resting directly on the frame as
in the prior art of Fig. 3.

Fig. 15 illustrates an exploded view of the
present invention which is commercially sold for
30 retrofitting to a Model 750 John Deere Grain Drill.
Its construction is similar to the first embodiment 50
with the principal difference being its illustration in
exploded form.

The present invention, as explained above in the various embodiments, may be configured in different geometrical constructions to provide a support which transfers the weight of seed grain 71 from the
5 hopper 16 to the frame 12 of grain drills of diverse designs to permit accurate sensing of the weight of the seed grain with the advantages as described above.

The overall process of utilizing the present invention to optimize the rate of planting of seed
10 grain with the grain drill is as follows. Initially, the farmer sets the control 34 to an estimated rate of planting of seed grain which the farmer believes to be as close as possible to the desired weight rate of planting per acre. After planting one or more acres,
15 the total acreage planted is determined from reading the count of the acreage counter 32 and is divided into the number of pounds of seed grain planted, as indicated by the decrease in weight of seed grain in the hopper 16 by the display 64, to determine the
20 actual weight of seed grain planted per acre. After the calculation of the actual weight of planting of seed grain per acre, the control 34 is adjusted upward or downward to move the rate of planting from the actual rate of planting, assuming it is different from
25 the desired rate of planting, toward the desired rate of planting. This process may go through one or more iterations until a highly accurate rate of planting is achieved.

While the present invention has been described in
30 terms of its preferred embodiment, it is intended that numerous modifications may be made thereto without departing from the spirit and scope of the invention. It is intended that all such modifications fall within the scope of the appended claims.